MSc. Dissertation

MechaMates

The Robot as a Constructionist “Object-to-Think-With” for Assimilation of Technology Education (& More)

Iterative Development Documentation

Contents

Electronics

V1 Requirements

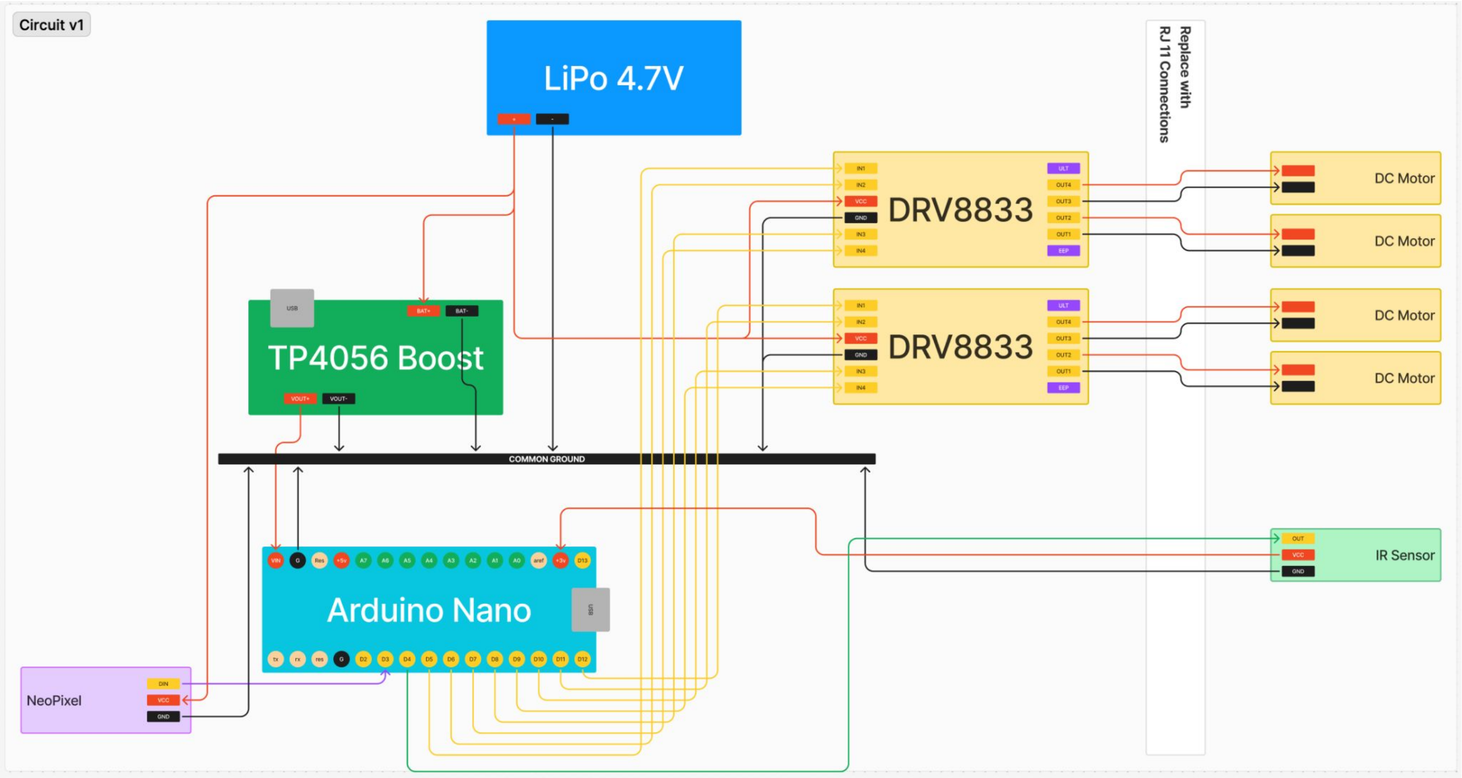
The first step in developing a POC was to design the electronics for the programmable brain.

The initial requirements were:

- 4 motor ports
- 4 sensory ports
- An 8X16 LED matrix for face
- A rechargeable battery to power the brain
- An Arduino Nano to program and communicate wirelessly with a desktop/mobile app with its onboard bluetooth component.

I finalised the components & circuit by seeking help from an electronics engineer friend who helped me identify the DRV8833 motor driver as a compact option for this use case, and the TP4056 boost charging module as a solution to both charge the battery and adjust output voltage for the Arduino.

V1 Circuit
link



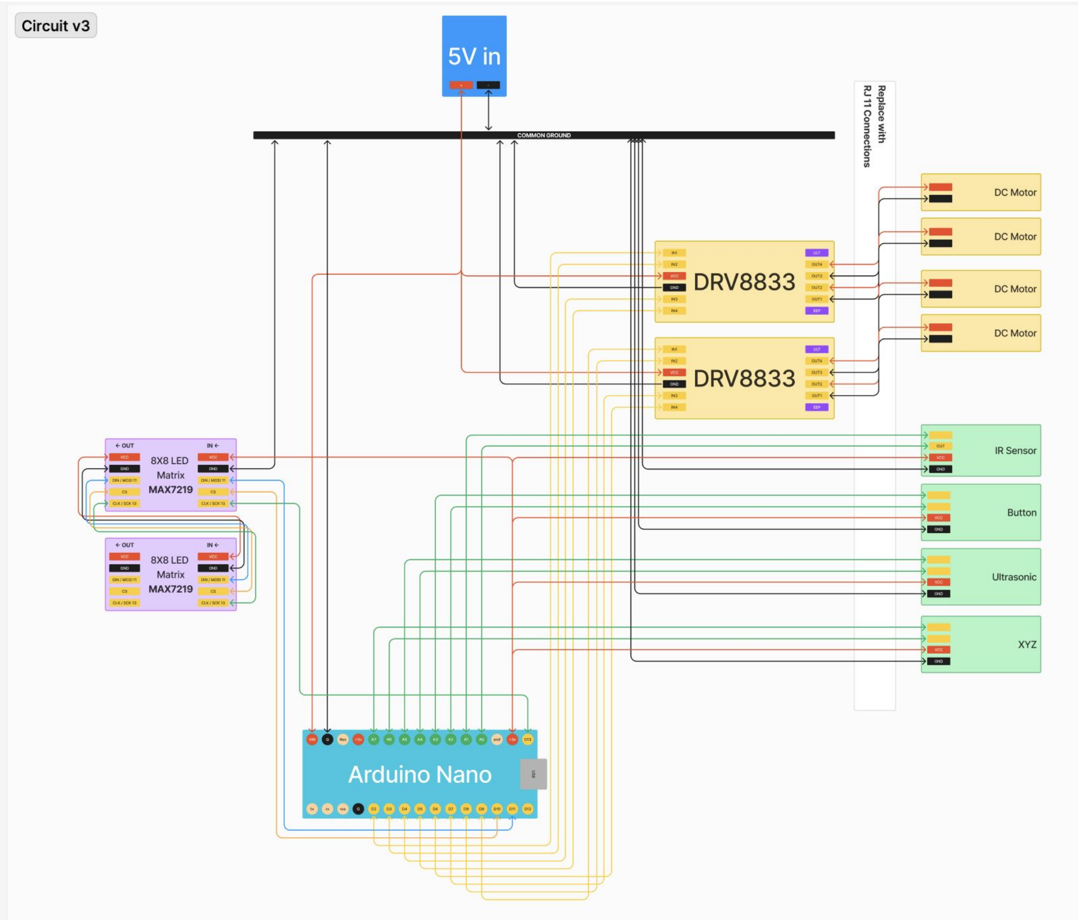
Final Requirements

By the final design, a couple of things changed:

- I decided to not use a battery for the POC because there were safety regulations that prevented the use of LiPo battery inside CCI labs. As a result the TP4056 module was also not needed.
- The NeoPixel 8x16 led matrix that I procured was large in size so I switch to the MAX7219 LED matrix.

Final Circuit

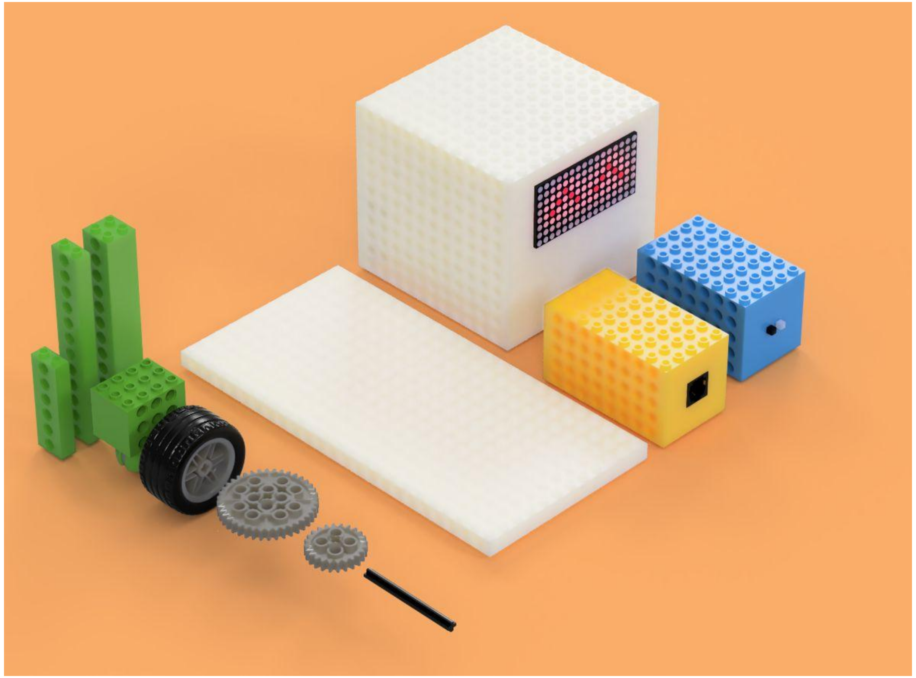
link



Construction Design System

Requirements

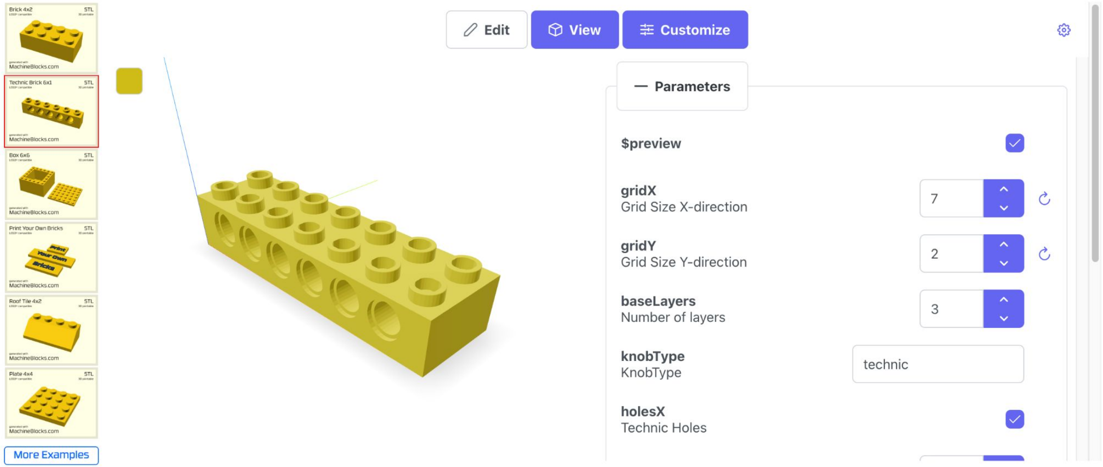
- Casing for the brain
- Casing for the motors
- Casing for the sensors
- A big base plate for bigger constructions
- Beams
- Wheels
- Gears
- Axle
- Pins



Prototyping

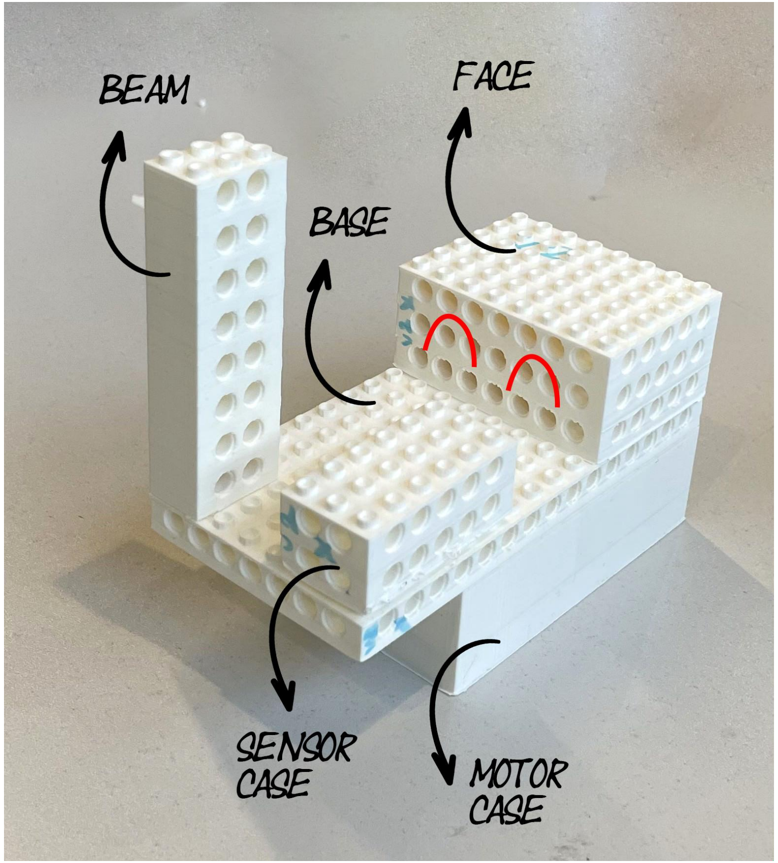
I decided on using the lego technic classic brick as an initial foundation to design this snap-fit ecosystem.

I found a portal online to render and create printable stl files for all lego technic parts - https://machineblocks.com/examples/technic-bricks



Initial Tests

I used the machine blocks portal mentioned in the previous slide for initial tests of part sizing.

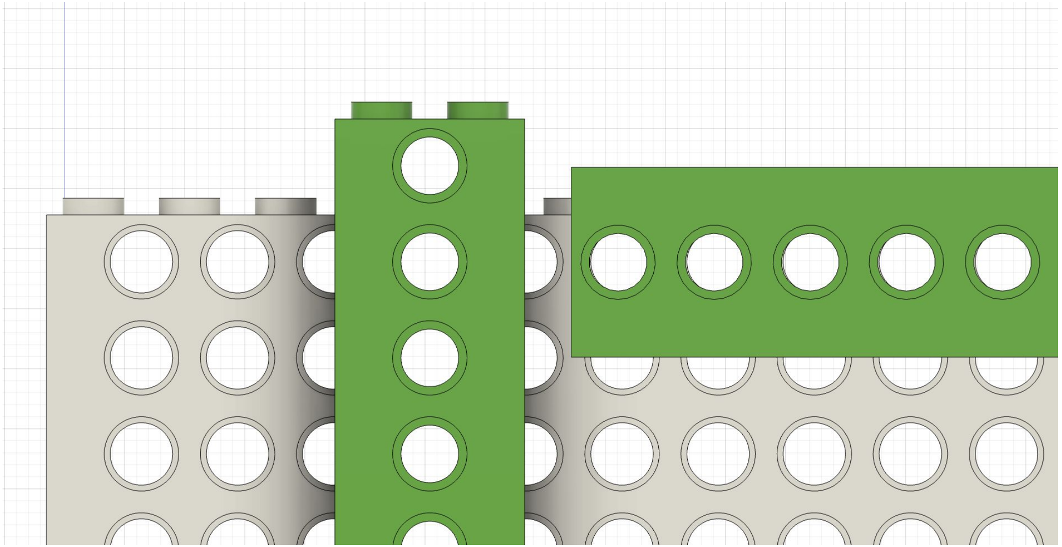


Key Challenge with Lego Technic

The one key challenge I identified about lego classic and technic bricks was that lego technic bricks do not connect to the lego classic bricks when connected vertically.

New Foundational Blocks

To overcome this challenge I redesigned the lego technic classic brick with a new height so traditional technic bricks could connect both vertically and horizontally.



Parametric Design in Fusion 360

I designed a parametric fusion 360 file to extract this block for any/all sizes.

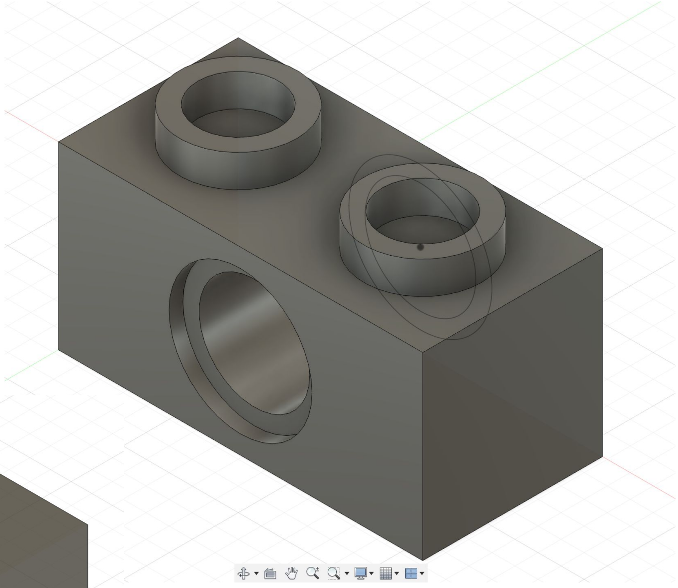
There were two designs because the bottom fitting designs were diff :

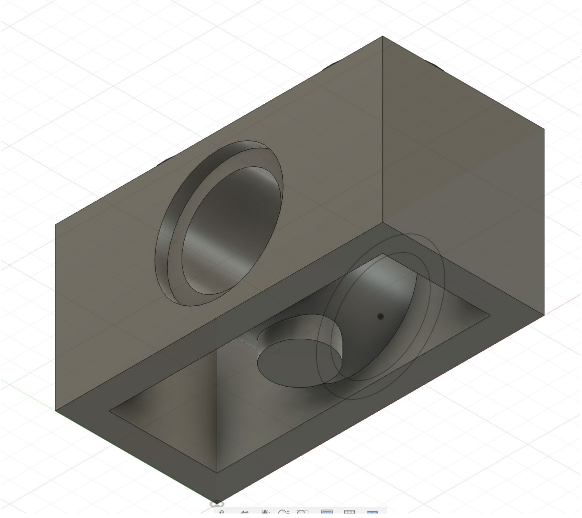
- Blocks with 1 hole width
- Blocks with 2+ hole widths

Parametric Design in Fusion 360

Blocks with 1 hole width

[Link to the Fusion360 file]()

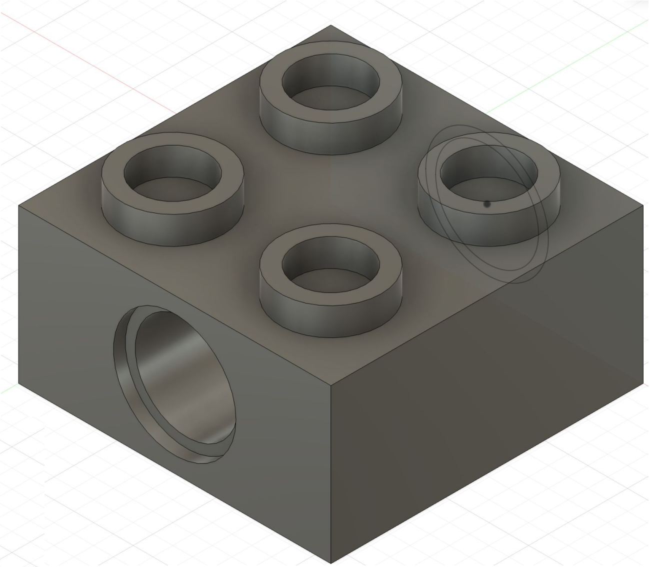


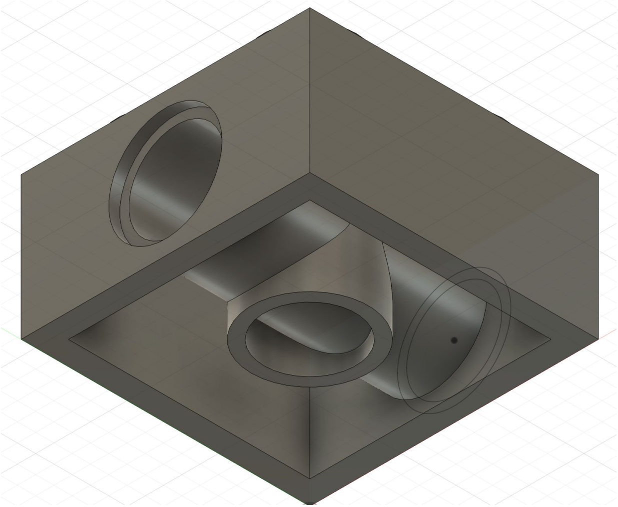


Parametric Design in Fusion 360

Blocks with 2+ hole width

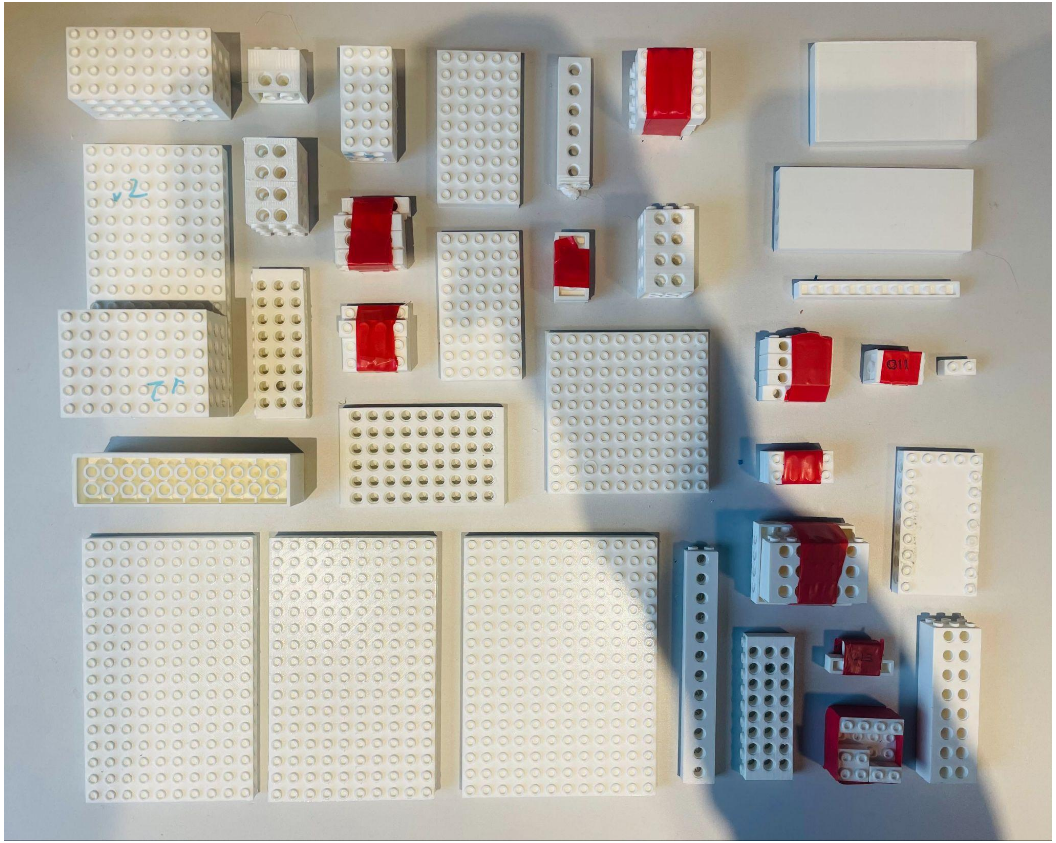
[Link to the Fusion360 file]





3D Printing Tests

A lot of tests were done to get the fittings right for all holes on the top, bottom and axle/pin fittings on the sides.



3D Printing Test Results

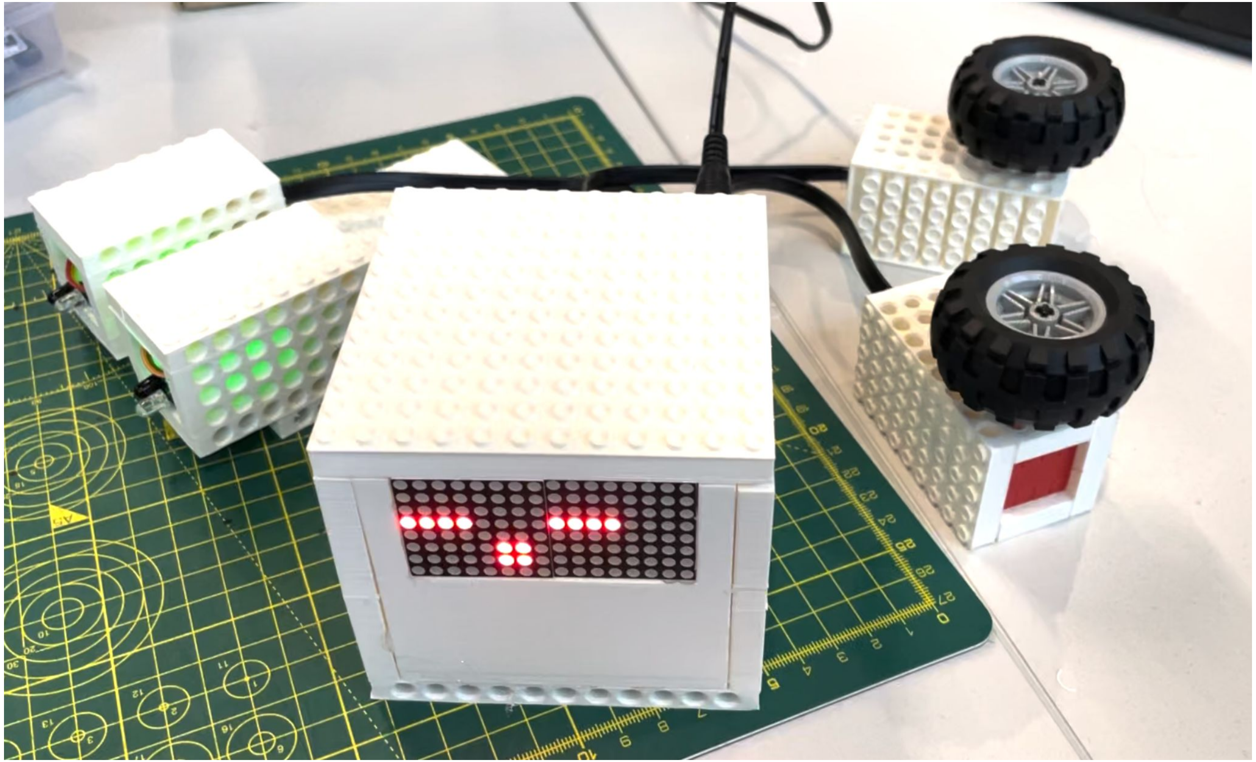
Results from the tests were systemically documented to reach the final template.

[Link to the detailed tabulated results]()

S No	Variant	Version	Grid	Base Layers	Top Knob Outer	Top Knob Inner	Knob Height	Brick Height	Shell (2+)	Shell 1	Bottom Dia 1	Side Inner Dia	Design Changes	Testing Results
001	Technic Bric 2X1	v3	3 X 2	3	5.0									
002	Brick 2X1	v3	12 X 3	9	5.0									
003	Technic Bric 2X1	v3	3 X 2	3	4.9									
004	Brick 2X1	v3	3 X 2	3	4.9									
005	Brick 2X1	v3	3 X 2	3	4.7									
006	Technic Bric 2X1	v3	3 X 2	3	5.0									
007	Custom classic technic brick				4.8	3.5	1.8							
008	Custom classic technic brick				4.8	3.5	1.4							
009	Custom classic technic brick				4.8	3.5	1.4						Bottom knob design as opposed to pin design	
010	Custom classic technic brick				4.8	3.5	1.4	7.4					Better fusion template	Classic knob and technic knob both a little tight
011	Custom classic technic brick				4.8	3.5	1.4	7.8						Good fitting but 2+ shell too loose
012	Custom classic technic brick				5.0	3.5	1.4	7.8	1.5					Shell too tight
013	Custom classic technic brick				5.1	3.5	1.4	7.8	1.3	1.5	3.2		1 width pieces too tight	
014	Custom classic technic brick				5.1	3.5	1.4	7.8	1.3	1.3	2.9	4.8		Good fitting but axle too tight
015	Custom classic technic brick				5.1	3.5	1.4	7.8	1.3	1.3	2.9	5.2		axle ok, pin loose
015	Custom classic technic brick				5.1	3.5	1.4	7.8	1.3	1.3	2.9	5.0		axle tight

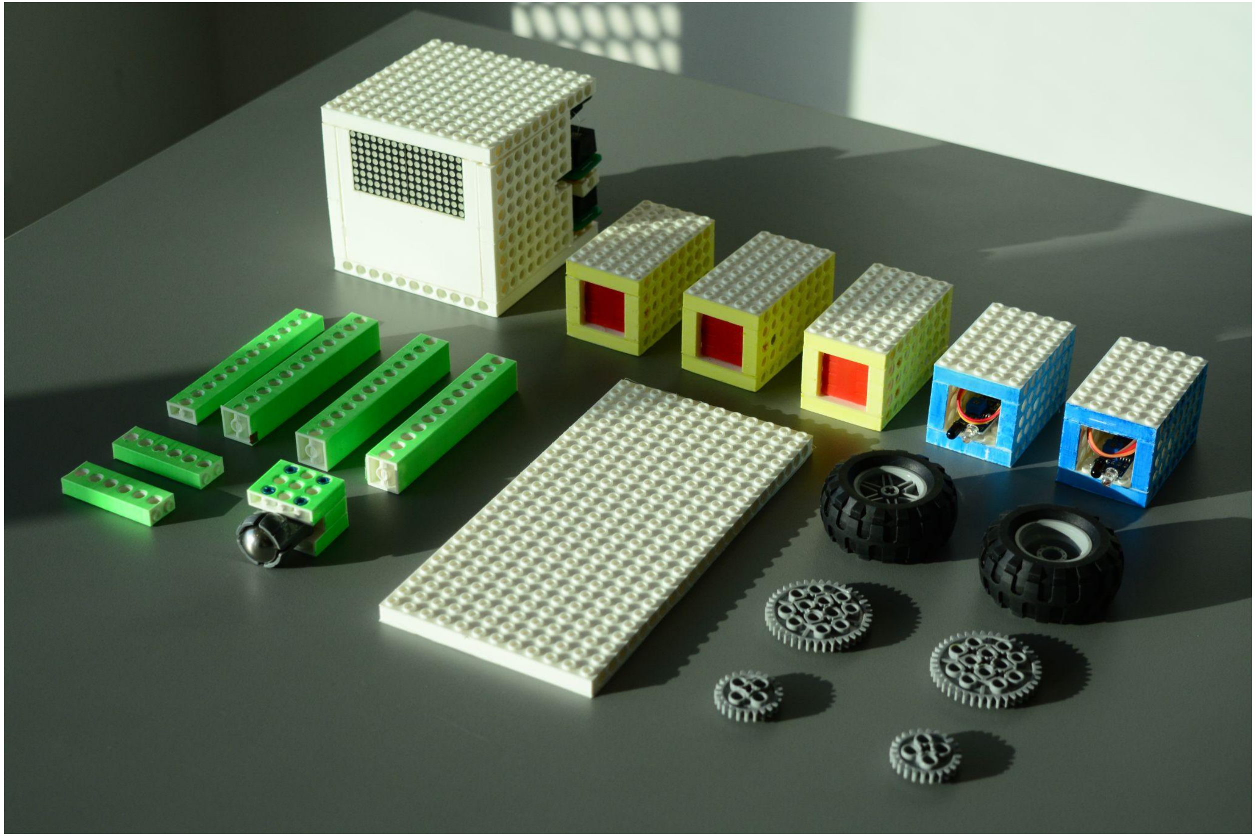
Casings

Casings were then designed for the motor, sensor and brain.



Painting

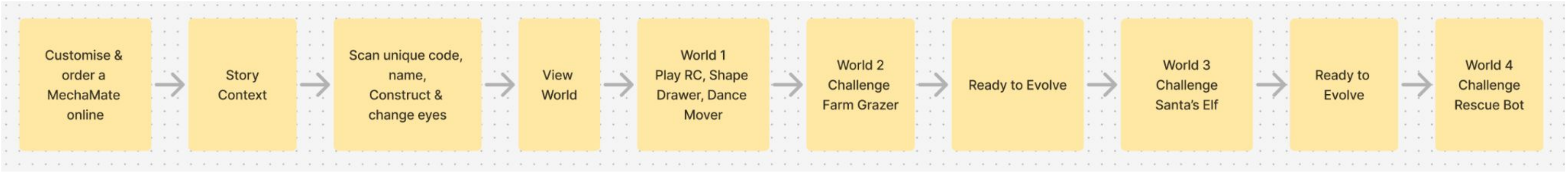
The parts were finally painted with some sharpies for the final POC.



User Interface

User Journey

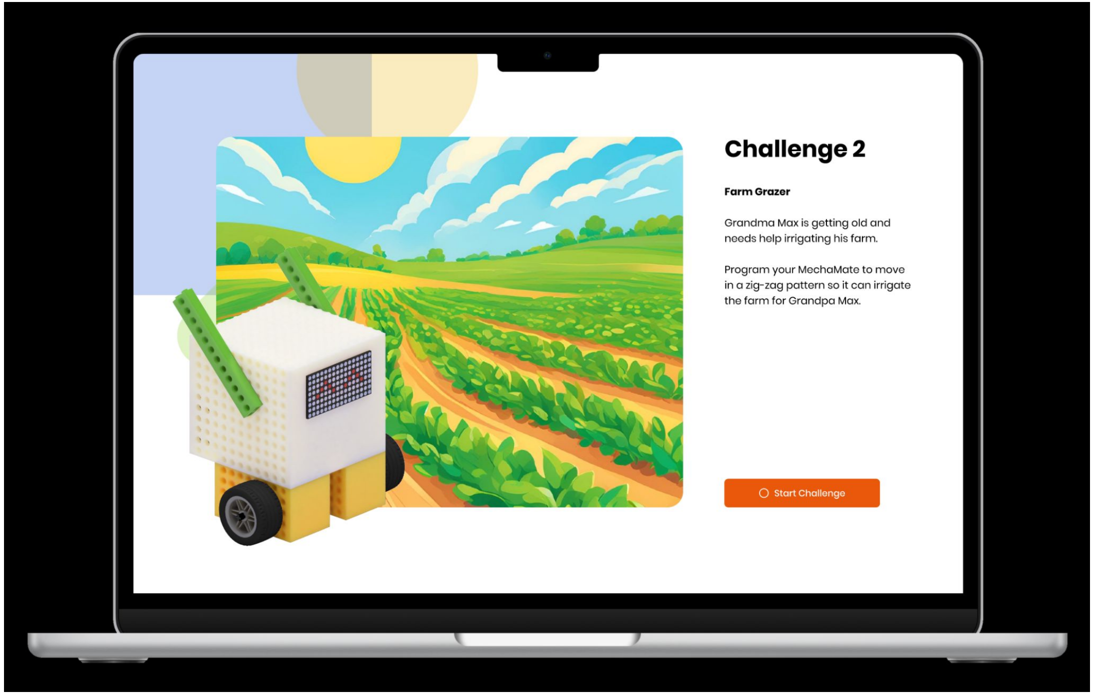
To design the user interface, I began by drafting a high level user journey.



Figma Clickable Prototype

The final screens were then designed in Figma with some artwork made in Illustrator and renders from Fusion 360.

The final clickable prototype can be found here - Link



Code

Code

Seperate codes were written for the brain code in Arduino IDE and Processing for the GUI which would communicate serially to pass the instructions to the Arduino when specific buttons were pressed in the GUI.

[Arduino Code]

[Processing Code]